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THE DEVONIAN SECTION OF ITHACA, N. Y.¹ PART II
THE DISCRIMINATION OF THE NUNDA-CHEMUNG
BOUNDARY

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Ithaca, N. Y.

[Concluded from page 598]

THE CHEMUNG GROUP OF HALL

The name Chemung group was originally proposed by James Hall in the *Third Annual Report* of the New York State Geological Survey (p. 324), published as "Assembly Document No. 275" in 1839. The formation was described and lithologically distinguished from the rocks of the immediately underlying formation by the following characteristics:

The tops of the hills and high grounds in the towns of Erie, Veteran, and Catlin, display a group of rocks and fossils very distinct from those last described. The essential difference is the lithological characters of the sandstone of this group in the absence of argillaceous matter in most of the layers, these being merely a pure siliceous rock, harsh to the touch, and generally of a porous texture; while still a large proportion of the mass consists of compact shales and argillaceous sandstones of a softer texture than those below. The surface of the sandstones is rough, while those below are smooth and glossy, and being never rippled, prove that the rocks were deposited in a quiet sea. (P. 322.)

This definition gives a fair idea of the most conspicuous differences separating the higher from the lower rocks of these sections,

¹ Published by permission of the Director of the United States Geological Survey. Concluded from p. 598 of Vol. XIV, No. 7 (1906).

though it would be difficult to draw a sharp line at the horizon where the change takes place.

The shales of the Nunda and Chemung are similar, but the sandstones of the Nunda are smooth surfaced, often ripple marked, thin and tough in texture; while they are soft, rough surfaced, breaking up with vertical rather than splintery fracture ("blocky" as I have called them), in the Chemung and are often of a lighter color.

In Hall's original definition of the formation certain fossils are mentioned as characteristic: "The principal ones are a species of *Delthyris* the shell on each side extending into a wing (*D. alata*?) a *Leptaena*, *Orthis*, and a species of *Avicula* or *Pterinea*," etc., but we find a fuller list given in the final report published in 1844. Still more important than this citation of fossils for the purpose of identifying the typical characteristics of the formation is the following statement:

Between Elmira and Chemung they are seen at numerous points, but nowhere in the county [Chemung] so well as at the Chemung upper Narrows, about eleven miles below Elmira. Here the excavation for the road along the margin of the river has exposed more than 100 feet of rocks, containing abundance of the characteristic fossils, and in their greatest beauty and perfection. (P. 323.)

This quotation indicates where may be found the typical representation of the fauna and, since in later papers the author [James Hall] lessened his belief in the separateness of the faunas of the Ithaca and Chemung, this standard section is important as it enables us now to scrutinize it more closely than Hall did and to discover the paleontologic marks by which it may be distinguished from the fauna underlying it.

Adopting therefore this section at the upper Chemung Narrows as containing the typical Chemung fauna, as recognized at the time of the original recognition and naming of the Chemung group by James Hall, we may select from the fossils named as characteristic of the Chemung group in the final report (1843) those which are known to belong to the section of rocks exposed at Chemung Narrows (*Geol. of Fourth Dist., N. Y.*, pp. 262 ff.).

The species originally mentioned by Hall as coming from the rocks at Chemung and Cayuta Creek¹ (the latter has been found by

¹ Ch.=Chemung; Cy.=Cayuta Creek.

later investigations to represent the same portion of the section as that seen at the cliff at the Narrows above Chemung) are the following, viz.:

- Calymene nupera (Fig. 116, p. 262, Ch.) = Phacops nupera.
 Avicula pectenformis (Fig. 117, 1, 2, p. 262, Ch., Cy.) = Pterinea chemungensis (Con.).
 Avicula spinigera (Fig. 117, 4, p. 262, Ch.) = Leptodesma spinigerum.
 Strophomena bifurcata (Fig. 120-2, Ch.) = Orthothetes chemungensis.
 Strophomena arctostriata (Fig. 120, 3, Ch.) = Orthothetes chemungensis.
 Strophomena interstitialis (Fig. 120, 5, Ch.) = Dovillina mucronata (Con.).
 Orthis carinata (Fig. 121, 1, Ch.) = Dalmanella carinata.
 Orthis interlineata (Fig. 121, 3, 4, Ch., Cy.) = Dalmanella tioga (Hall).
 Delthyris mesastrialis (Fig. 122, 1, 1a, Cy.) = Spirifer mesistrialis.
 Delthyris disjuncta? H. (Fig. 122, 3, Ch.) = Spirifer disjunctus Sowerby.
 Delthyris cuspidata H. (Fig. 123, 1, Ch., Cy.) = Sp. disjunctus Sow.
 Delthyris acanthota H. (Fig. 123, 2, 2a, Ch., Cy.) = Sp. disjunctus Sow.
 Delthyris acuminata H. (Fig. 123, 5, 5a, Ch., Cy.) = Delthyris mesicostalis.
 Atrypa dumosa (Fig. 124, 1, 1a, Ch., Cy.) = Atrypa spinosa (Hall).
 Atrypa tribulis (Fig. 124, 3, Ch.) = Atrypa reticularis (Lin).
 Cyathophyllum p. (Fig. 273, Ch.) = ?

Conrad¹ in 1842 described several species, the locality of which is sufficiently well certified to refer them to this fauna. The species are (all from Chemung Narrows):

- Avicula spinigera (p. 237, Pl. 12, Fig. 3) = Leptodesma spinigerum (Con.).
 Avicula protexa (p. 238, Pl. 12, Fig. 6) = Leptodesma protextum (Con.).
 Avicula multilineata (p. 241, Pl. 13, Fig. 1) = Avicula multilineata (Con.).
 Avicula chemungensis (p. 243) = Pterinea Chemungensis (Con.).
 Cypricardites carinifera (p. 245, Pl. 13, Fig. 14) = Goniophora chemungensis.
 Inoceramus chemungensis (p. 246, Pl. 13, Fig. 9) = Mytilarca chemungensis (Con.).
 Nuculites chemungensis (p. 247, Pl. 13, Fig. 13) = Schizodus chemungensis (Con.).
 Strophomena lachrymosa (p. 256, Pl. 14, Fig. 9) = Productella lachrymosa (Con.).
 Strophomena lima (p. 256) P. lachrymosa var. lima (Con.).
 Strophomena mucronata (p. 257, Pl. 14, Fig. 10) = Douvillina mucronata (Con.).
 Strophomena chemungensis (p. 257, Pl. 14, Fig. 12) = Orthothetes chemungensis.

¹ "Observations on the Silurian and Devonian systems of the United States with Descriptions of New Organic Remains," *Jour. Acad. Nat. Sci.*, VIII (Jan. 18, 1842), pp. 228, etc.

Strophomena delthyris (p. 258, Pl. 14, Fig. 19) = (?) *Leptostrophia perplana*.

Delthyris chemungensis (p. 263) = *Spirifer disjunctus*.

Atrypa chemungensis (p. 265) = *Atrypa reticularis*.

In the Final Reports on Paleontology,¹ a large number of species were added to these lists, but for the purpose of determining the typical Chemung fauna and settling its lower boundary these species should furnish conclusive evidence. Those of the list which are restricted in range in this original section may fairly be regarded as diagnostic of the Chemung formation at its typical outcrop.

The two lists contain the following twenty species:

- | | |
|---|--|
| 1. <i>Phacops nupera</i> (Hall). | 11. <i>P. lachrymosa</i> var. <i>lima</i> (Hall). |
| 2. <i>Pterinea chemungensis</i> (Hall). | 12. <i>Stropheodonta</i> (<i>Douvillina</i>)
<i>muconata</i> (Vanuxem). |
| 3. <i>Leptodesma spinigerum</i> (Conrad). | 13. <i>Leptostrophia</i> (? <i>perplana</i>) |
| 4. <i>L. protextum</i> (Conrad). | <i>delthyris</i> (Conrad). |
| 5. <i>Avicula multilineata</i> (Conrad). | 14. <i>Dalmanella carinata</i> (Hall). |
| 6. <i>Goniophora chemungensis</i>
(Conrad) | 15. <i>Dalmanella tioga</i> (Hall). |
| 7. <i>Mytilarca chemungensis</i> (Conrad). | 16. <i>Spirifer disjunctus</i> (Sowerby). |
| 8. <i>Schizodus chemungensis</i> (Conrad). | 17. <i>Spirifer mesistrialis</i> (Hall). |
| 9. <i>Orthotheses chemungensis</i> (Hall). | 18. <i>Delthyris mesicostalis</i> (Hall). |
| 10. <i>Productella lachrymosa</i> (Hall). | 19. <i>Atrypa spinosa</i> (Hall). |
| | 20. <i>Atrypa reticularis</i> (Linn). |

Of these species No. 1, *Phacops nupera*, is a variety of the common species *P. rana*, if not identical; but it was obtained from a loose block, as we are told in *Paleontology*, Vol. VII, p. 27, so that it is not certainly a part of the original Chemung fauna.

No. 5, *Avicula multilineata*, is not referred to in later literature, and for correlation purposes it is too rare to serve as a diagnostic species.

No. 8, *Schizodus chemungensis*, is reported as from "near Ithaca and Cortland,"² and as the rocks of these localities are now known to lie at a horizon lower than the rocks of Chemung Narrows, the species ceases to be diagnostic of the latter formation.

No. 9, *Orthotheses chemungensis*, as a species has a considerable range: it is quite variable in its Chemung expression, so that the name without restriction will not constitute it a diagnostic species of the Chemung.

¹ *Paleontology of New York*, Vols. IV, V, VI, VII, and VIII.

² *Paleontology of New York*, Vol. II, p. 454.

No. 13, called *Strophomena delthyris* by Conrad, is quite distinct from the form described by the same name under the name *Strophomena perplana* to which it has been referred by Hall. If it be a variety of *Str. perplana* Conrad, it is sufficiently distinct to receive a distinct varietal name, and then will appear as *Leptostrophia perplana delthyris* (Con.).

Hall did not recognize the species called by him *Strophomena nervosa*¹ as coming from the Chemung Narrows section; nor does he list it from that section in the final description of the variety.² It may therefore be discarded from a strictly diagnostic list.

No. 17, *Spirifer mesistrialis*, in the final description of the species is listed from near Cortlandville in Cortland County. The rocks there exposed are stratigraphically at a lower horizon than Chemung, so that the species will not serve to settle the question as to whether the Chemung fauna is or is not identical with that of the Ithaca member.

No. 18, *Delthyris mesicostalis* Hall. This species was described from a specimen from Angelica, N. Y., and was not reported by Hall from the Chemung Narrows section. The form which has later been identified as of this species, was originally described as *Delthyris acuminata* by Hall; this specific name was dropped because it had already been used by Conrad for a Spirifer. This latter form was recognized by Hall as coming from Ithaca, and Cayuta Creek.³

This form (referred to by Hall under the name *Delthyris acuminata*) is a common Chemung species; but the discovery of its intimate association with the Tropicodoleptus fauna, its close affinity with *Delthyris consobrinus* (also a Hamilton species), and its occurrence in the Van Etten and White Church zones of Tropicodoleptus entirely below the range of *Spirifer disjunctus*, the Dalmanellas, the Douvillinas, and *Pterinea chemungensis*, has led me to believe that it does not belong to the typical Chemung fauna, any more than do *Tropicodoleptus carinatus* and *Rhipidomella vanuxemi*, both of which are abundant in some zones of the section at Chemung Narrows.

Independently, therefore, of the question as to whether there is

¹ *Final Rept. Fourth Dist.* (1843), p. 266, Fig. 1.

² *Paleontology*, etc., Vol. IV, 113, 114.

³ *Report Fourth Dist. N. Y.* (1843), p. 271.

a distinction between the Ithaca and Chemung forms going under the name, this species cannot be regarded as strictly diagnostic of the typical Chemung fauna.

Nos. 19 and 20, *Atrypa spinosa* and *Atrypa reticularis*, are both recorded from lower horizons than the Chemung by Hall in the *Paleontology of New York*,¹ so that they too must be discarded from the list as not strictly diagnostic of the fauna.

DIAGNOSTIC SPECIES OF THE TYPICAL CHEMUNG FAUNA

Excluding the above mentioned species there are left the following eleven species characteristic of the original Chemung group, as expressed in the section at Chemung Narrows a few miles west of the town of Chemung, viz.: *Pterinea chemungensis*, *Leptodesma spinigerum*, *Leptodesma protectum*, *Goniophora chemungensis*, *Mytilarca chemungensis*, *Productella lachrymosa*, *P. lachrymosa lima*, *Stropheodonta (Douvillina) mucronata* (Van.), *Dalmanella carinata*, *Dalmanella tioga*, *Spirifer disjunctus*. The question may appropriately be raised what is the known vertical range of these species, and how sharply may the Nunda-Chemung boundary be drawn by means of their appearance in the rocks?

Range of the species.—The first species, *Pterinea chemungensis* (Conrad), is reported only from this Chemung locality and formation in the *Paleontology of New York*.² In that volume several closely allied species are described; in the case of none of the species is a locality or range indicated which would exclude them from this fauna. The species are *Pterinea consimilis* Hall, from Bucks quarry and Chemung, Chemung County, and Smithboro, Tioga County; *Pterinea rigida* Hall, from several localities in Chemung County; *Pterinea prora* Hall, from Bucks quarry and Chemung upper Narrows; also *Pterinea (Vertumnia) reversa* Hall, and *Pterinea (Vertumnia) avis* Hall; the subgenus *Vertumnia* was erected on the character of reversal of the characters of the opposite valves of the shell so that the right valve of *Vertumnia* appears like the left valve of typical *Pterinea*. The species of *Vertumnia* are also restricted to the horizons through which the normal species range.

¹ *Op. cit.*, Vol. IV, 1867, pp. 321, 325.

² *Op. cit.*, Vol. V, 1884, p. 98.

In the sections examined in the Watkin's Glen quadrangle the range of all these species of *Pterinea* is restricted to the Cayuta member of the Chemung formation, as defined in this paper, except in a few doubtful cases where the species run higher up than the supposed termination of the Cayuta member into the Wellsburg.

Eastward, in the Harford quadrangle, the species *Pterinea chemungensis* has been discovered at a horizon below the range of the other species of the Chemung fauna. The fauna with which it is there associated is however sufficiently distinct from the typical Chemung fauna to leave little doubt as to a lower horizon. In one case Clarke has reported it at the extreme eastern edge of the Harford quadrangle in association with *Stropheodonta cayuta*.¹ Neither of those species has been discovered in the Watkin's Glen quadrangle below the base of the Chemung formation. Clarke also records *Stropheodonta cayuta* in the West Hill sandstone of the Canandaigua and Naples quadrangles² and in the West Hill flags and shales of the Watkins and Elmira quadrangles.

While a failure to discover fossils is no evidence that they are wanting, it may be stated that none of the surveying party with the present writer examining the rocks of the Watkins Glen quadrangle has discovered either the *Pterinea* or the *Douvillina* below the stratigraphic base of the Chemung, thus making both of these species a fairly satisfactory evidence of a Chemung horizon for the Watkins Glen quadrangle, though it is not possible to say that they do not appear at a lower level within this province.

Leptodesma spinigerum and *Leptodesma protextum* are recorded from Chemung Narrows and both occur in the Chemung section there. They, however, vary so greatly in form and differ so slightly from the typical *Leptodesma Rogersi*; and there are so many species defined upon slight differences of form, that it will be difficult, without a more exhaustive study than has been given them to use species of this genus in defining the limits of the Chemung fauna. From the fact of the frequent abundance of species of this genus in the zones carrying such other species as *Tropidoleptus carinatus* and *Rhipidomela vanuxemi*, I am inclined to think that they belong to the

¹ N. Y. State Mus. Bull. 82, 1905, locality number 2499, pp. 53-70.

² N. Y. State Mus. Bull. 63, 1904, p. 64.

incursions of the Hamilton species into the region, rather than to the typical Chemung fauna. The Leptodesmas are not abundant in typical Chemung faunules although they are abundant in zones included in the Chemung formation.

Goniophora chemungensis (Van.).—In Hall's monograph on the Devonian Lamellibranchiata¹ this species is recorded from only the localities "Chemung Narrows and near Owego and Binghamton," all of which localities are estimated to be within the same stratigraphic limits, i. e., the Chemung.

In citing the above specific name, it should be noted that the original of the species named *Chemung cypricardite* (*C. chemungensis*) by Vanuxem² came from a locality "at the small bridge on the road to Lisle from Binghamton;" and the specimen coming from Chemung Narrows was described under the name *Cypricardites carinifera* by Conrad.³

Also, a closely related form was described by Conrad under the name *Cypricardites carinata* from "near Oneonta."⁴ This latter specimen is figured on Plate II of the *Fifteenth Annual Report of the State Museum*.⁵ Its close resemblance to the form figured by Vanuxem is evident. In fact Hall expressed his opinion that the original of Conrad's species *Cypricardites carinatus* is identical with Vanuxem's *Cypricardites chemungensis*;⁶ but in his final monograph (above referred to), he recognized the two species as distinct. Thus in a critical case of identification, when stratigraphic horizon is in doubt, care should be taken to make clear the actual difference in form between the Hamilton form of the genus and the higher one coming from the Chemung. The horizon of the locality from which the original of Conrad's species *Goniophora carinata* came is in dispute. Its association with *Paracyclas lirata* does not prove it to belong to the Hamilton fauna, as pointed out by Prosser.⁷ While the species

¹ *Paleontology of New York*, Vol. V, Pt. I, ii (1885), p. 303.

² *Rept. Third Dist. N. Y.* (1842), pp. 179, 181.

³ *Jour. Acad. Nat. Sci.* (1842), Vol. VIII, p. 245.

⁴ *Fifth Ann. Rept. N. Y. Geol. Surv.* (1841), p. 53.

⁵ 1862, Pl. II, Fig. 21.

⁶ Hall and Whitfield, *Preliminary Notice of the Lamellibranch Shells*, etc. (1869), p. 44.

⁷ *Seventeenth Ann. Rept. State Geologist, N. Y.* (1900), p. 80.

described by Conrad as *Cypricardites carinifera* and that named and figured by Vanuxem as *Cypricardites chemungensis* undoubtedly occur at Chemung Narrows in the typical Chemung fauna, the characters by which they may be discriminated from other representatives of the same genus at horizons below the range of other typical Chemung species are too vaguely established to make certain that the species is confined to the Chemung formation. Closely related species of the genus do certainly occur below and probably above the Chemung formation.

Mytilarca chemungensis.—As a genus *Mytilarca* ranges throughout the Devonian and upward into the lower formations of the carboniferous and both the elongate form *M. chemungensis* and the shorter form *M. carinata* are frequently met with in the Chemung rocks. Several other species have been described from rocks of other than the typical section referred to the Chemung formation. The forms from the Ithaca and lower horizons most closely resembling the Chemung species are more gibbous, and upon this character and the more narrow form of the Chemung representatives of the genus they may be distinguished. So that this species and its closely related species may be used as strongly suggesting, if not strictly indicative, of a Chemung horizon.

One of the localities (2517) referred to by J. M. Clarke in the paper before mentioned as containing *Pterinea chemungensis* is also reported as holding *Mytilarca chemungensis*. Another significant species is *Leptostrophia nervosa*. The combination is one suggesting the Chemung fauna but the horizon is not clear. Clarke reports the locality as "Ithaca beds."¹

Productella lachrymosa (Con.) and *P. lachrymosa var. lima* (Con.).—There is no doubt that forms of the genus *Productella* falling strictly under the description of Conrad's species *Strophomena lachrymosa* are present in the typical Chemung zone at Chemung Narrows as well as the variety *S. lima*. The question may be raised, however, whether this species is diagnostic of the Chemung fauna in New York state. Examination of a large number of faunules containing representatives of the genus demonstrate that the prominent characteristics of *P. lachrymosa*, i. e., the ventricose general form, large

¹ N. Y. State Mus. Bull., 82, p. 60.

size for the genus and elongate tubercles scattered sparsely over the surface, become conspicuous at the horizon where the line between Nunda and Chemung is drawn. Nevertheless, specimens occur below this line which might be referred to the species, though they do not express the dominant characteristics of the species at these lower horizons. The dominant forms in the faunules below the line differ either in size, and thus become referable to the species *P. shumardiana* or *P. spinulicosta*; or else differ in the surface markings and fall under the definition of *P. speciosa* in which also the form is less ventricose and the initial umbonal portion is relatively sharper and narrower in relation to the full dimensions of the shell. The Chemung fauna is therefore characterized by the presence of *Productella lachrymosa* and its variety *P. lima*, but on account of the great plasticity of the genus, and the fact that the genus is abundantly represented in the Brachiopod faunules anywhere above the Genesee as at present defined, it cannot be said that the species as defined is strictly diagnostic of a Chemung fauna and horizon.

Stropheodonta (Douvillina) mucronata (Con.).—This species was originally described by Conrad under the name *Strophomena mucronata*, from Chemung Narrows, associated with *Productella lachrymosa*.¹ It was next referred to by Hall under the name *Strophomena interstitialis*. Hall regarded it at that time as identical with Phillips' species of that name.² Later Hall described the same species as a new species under the name *Stropheodonta cayuta*,³ applying the name proposed by Conrad to the form occurring abundantly at Ithaca which had been already well figured by Vanuxem⁴ under the name *Strophomena interstitialis*. Hall thus confused under the specific name *mucronata*, both species which he distinguished in the separation of the original figures in his report as 5 and 5a from 5b and 5c, referring the latter two, which present the typical character of Conrad's description to a new specific name *Stropheodonta cayuta*, and applying Conrad's name to the first two of the set which do not offer the distinctive characteristics of Conrad's description. The result,

¹ Conrad, *Jour. Acad. Nat. Sci.* (1842), p. 257, Pl. 14, Fig. 10.

² Hall, *Geol. Fourth Dist. N. Y.* (1843), p. 266, Fig. 5.

³ Hall, *Paleogeography of New York*, Vol. V (1867), p. 110.

⁴ Vanuxemi, *Geol. N. Y. Rept. Fourth Dist.* (1842), p. 174.

which has come to light in noting the subgeneric differences indicated by the names *Leptostrophia* H. and C. and *Douvillina* Oehlert, is that the species characteristic of the Chemung fauna of New York, is the one originally described by Conrad from Chemung Narrows. This species belongs to the subgenus *Douvillina* and is properly therefore named *Stropheodonta (Douvillina) mucronata* (Con.).

All the faunules collected by the writer's party in the Watkin's Glen and Catatonk quadrangles which contain this species offer no evidence to contradict their reference to the Chemung fauna and Chemung formations as defined in this paper. No case has been discovered by them of the presence of the species at a horizon below the Chemung base. In the two quadrangles 183 faunules have been examined containing this species and of none of them is there any reasonable doubt (either structural or paleontological) as to their stratigraphic position above the Nunda-Chemung boundary as established in this classification.

A faunule from Marathon reservoir, R. Ruedemann collector, No. 2499, is reported by J. M. Clarke as belonging to the "Ithaca beds."¹ Although the altitude is not given several of the species named do not indicate a horizon so low as the Ithaca. The species listed are:

Tentaculites sp. incert; *Actinopteria* etc. (Hall); *Pterinea chemungensis* (Con.); *Grammysia bisulcata* (Con.); *Microdon bellistriatus* (Con.); *Nucula varicosa* (Hall?); *Palaeoneilo emarginata* (Con.); *P. tenuistriata* (Hall); *P. sp. incert*; *Schizophoria impressa* (Hall); *Leptostrophia mucronata* (Con.); *Stropheodonta cayuta* (Hall); *Str. cf demissa* (Con.); *Chonetes scitula* (Hall); *Productella lachrymosa* (Con.); *P. sp. incert*; *Spirifer mucronatus* (Con.); *S. mucronatus posterus* (H. and C.); *S. mesastrialis* (Hall); *S. laevis* (Hall); *Atrypa reticularis*; *Cyrtina hamiltonensis* var. *recta* (Hall); *Pugnax pugnax* var. *altus* Calv.; *Leiorhynchus globuliformis* (Van); *Strictopora gilberti*; *Hederella*; *Plumalina plumaria* (Hall); *Taxocrinus*; *Auloprora*; *Boring sponge*; *Lepidodendron*; *Dadoxylon*.

The species whose place in this list seem to the writer questionable are *Pterinea chemungensis*, *Stropheodonta cayuta*, and *Productella lachrymosa*. If these species are correctly identified and occur in association with the other species listed they are not in accord with the evidence gathered by our party at Marathon, and in fact throughout the whole of the Catatonk quadrangle.

¹ N. Y. State Mus. Bull. 82, pp. 59 ff.

Dalmanella carinata Hall is described as coming from the localities Painted-Post, Chemung, and Jasper¹ under the name *Orthis carinata*. But in the final description of the species² it is referred to Painted-Post alone. The statement is made that it "has not been obtained from any other locality,"³ and we are told that in many of its characters this species assimilates with *Orthis tioga* and one of the localities from which *Orthis tioga* is cited is Chemung Narrows. Hence we may infer that the species selected as typical of the Chemung Narrows section is *Orthis tioga*, and although *O. carinata* has been discovered there, Hall evidently changed his opinion as to the Chemung Narrows form while the final report on Paleontology was being prepared.

Dalmanella tioga Hall.—This species was originally described and figured by Hall⁴ under the name *Orthis interlineata* Sowerby. It was later described by him under the name *Orthis tioga*.⁵ Still later it was placed by Hall and Clarke in the genus *Schizophoria* King.⁶ And in the year 1905 the characters of the species were shown by Williams to be those of the genus *Dalmanella*, not *Schizophoria*.⁷ It was pointed out by Williams that in *Schizophoria* the pedicel valve is resupinate, and, in the upper Devonian forms, presents a distinct sulcus along the center of that valve. The pedicel valve of *Dalmanella* on the other hand is distinctly elevated into a fold or narrow ridge, and in that genus the valve with the sulcus is the brachial valve, which is always convex in *Schizophoria*. There are other internal characters to separate the two genera, but the above external characters are sufficiently large and conspicuous to be detected in the field and furnish the evidence of the genus *Dalmanella*, by which presence of the Chemung fauna may be established for this province. The genus was prominent in the Ordovician and Silurian and appears conspicuously in the lower Helderberg. The only report of the genus

¹ *Geol. N. Y. Rep. Fourth Dist.* (1843), p. 267, Fig. 1.

² *Paleontology of New York*, Vol. IV (1867), p. 58, Pl. 8, Fig. 30-32.

³ *Loc. cit.*, p. 59.

⁴ *Geol. N. Y. Rept. Fourth Dist.* (1843), p. 268, Figs. 3, 4.

⁵ *Paleontology of New York*, Vol. IV (1867), p. 59, Pl. VIII, Figs. 20-29.

⁶ *Op. cit.*, Vol. VIII, Pt. 1, 1892, pp. 212, 226, Pl. VI, Figs. 17, 18.

⁷ *U. S. Geol. Sur. Bull.* 244 (1905), p. 86.

from the Hamilton is the case of the minute species *Dalmanella lepidus* Hall, reported to have been found in only a single locality on the shore of Canandaigua Lake, Ontario County, N. Y., and in few individuals.¹ In the great number of faunules gathered and examined from the sections now under investigation and the neighboring regions of the Watkins Glen and Catatonk quadrangles not a trace of the genus *Dalmanella* has been seen below the Nunda-Chemung boundary line (i. e., not in the Nunda, Ithaca, Genesee, or Tully formations). In the Chemung rocks, however, the genus is represented by at least three species, and in some zones abundantly.

The species *Dalmanella tioga* is common and often met with in the Chemung rocks of this section from a horizon, 100 feet above the base upward for five hundred feet where it becomes less frequent.

In the first one hundred feet it is represented by the smaller species *Dalmanella leonensis*, which in some zones is abundant; but this species has not been recognized in this region above about one hundred feet from the base of the Chemung formation.

The genus has been observed in seven faunules from the Watkins fifteen-minute quadrangle. In all these cases the faunules present other indications of a horizon at the base of the Chemung and the line has in all cases been drawn to include the genus in the Chemung formation.

In the Elmira quadrangle the genus has been observed in fifty-one faunules, and in all of them the evidence, on other grounds, leaves no doubt as to the Chemung horizon of the strata containing them.

Twenty-nine faunules from the Ithaca quadrangle are equally clear as to the stratigraphic horizon to which the species of this genus belong.

From the Waverly quadrangle eighty faunules contain one or other species of the genus, and regarding none of them is there doubt as to the stratigraphic horizon to which they belong.

From the Dryden quadrangle fifteen faunules hold representatives of the genus.

In the Owego quadrangle the genus has been seen in seven faunules.

In the Apalachin quadrangle three cases have been recorded;

¹ *Paleontology of New York*, Vol. IV (1867), p. 46.

but no faunule has been discovered in the Harford quadrangle containing a species of *Dalmanella*.

Clarke cites no case of a *Dalmanella* in the list of species recorded from Central New York in the Ithaca fauna.¹ I have not observed in the various papers written by C. D. Prosser any report of a species of *Dalmanella* (or a species recorded under the name *Orthis*, now known to be *Dalmanella*) from the Devonian of Chenango Valley or further east in New York State, except the one case of *Orthis lenticularis* Van., from Chapman's Quarry, Babcock Hill, which is a typical Corniferous limestone.²

These facts indicate that eastward of the Ithaca meridian *Dalmanella* rapidly becomes rare and is rarely seen in Upper Devonian faunas beyond the Apalachin quadrangle eastward.

Tracing the evidence westward Clarke cites the species *Orthis injera* Calvin, which is a *Dalmanella*, from the fauna of the High point sandstone of Naples.³ This species is small and closely related to *Orthis leonensis*. From the same fauna are cited also *Stropheodonta cayuta* and *Spirifer disjunctus*, thus leaving no doubt as to the Chemung character of the fauna.

In the Genesee Valley the genus is frequently met with in association with typical Chemung faunules.⁴ In only one case in that bulletin is it reported from a doubtful horizon. This is the case of the shales at Hornellsville, Station No. 494. Here it occurs with *Cardiola (Buchiola) speciosa* and other species of the Nunda fauna. It is followed immediately by beds carrying *Spirifer disjunctus*. The species there is *Dalmanella leonensis*. This, with our present knowledge, locates the Hornell horizon in the *Dalmanella leonensis* zone at the base of the Cayuta member of the Chemung. A similar association takes place in the early faunules of the Watkins Glen and Elmira quadrangles, which indicates an over-lapping of the Nunda species upon the first incursion of the Chemung fauna. Still farther west in Chautauqua County the earlier Chemung faunas

¹ "Ithaca Fauna of Central New York," *N. Y. State Mus. Bull.* 82, pp. 53-70.

² "Devonian Section of Central New York," *N. Y. State Geol. Twelfth Ann. Rept.* (1894), p. 5.

³ *N. Y. State Mus. Bull.* 63, p. 64.

⁴ *U. S. Geol. Survey, Bull.* 41, pp. 30, 67, 69, 74, 76, 80, 85.

contain the smaller form of the genus called *Orthis* (*Dalmanella*) *leonensis*.

In the Chemung rocks of western New York the genus is almost as conspicuous as *Spirifer disjunctus* or *Orthotheses chemungensis*.

Taking in all the evidence the conclusion is drawn that *Dalmanella* is a characteristic genus throughout the whole Chemung in the western New York section; is more rarely present in the faunules of Genesee Valley; is conspicuous in the early and middle zones of the Chemung in the sections of Watkins Glen quadrangle; is rare in the Catatonk quadrangle, and is rarely ever seen further eastward.

The species *Orthis* (*Dalmanella*) *tioga* Hall,¹ was described from specimens derived near Factoryville in Tioga County, along Cayuta Creek, at Chemung Narrows, near Elmira, at Horseheads, and at Bucks quarry. It was also obtained from Allegany County at Phillipsburg, and near Leon and other places in Cattaraugus County, N. Y.

The species *Orthis* (*Dalmanella*) *leonensis* Hall,² is a smaller species and in the original description it is cited only from the Chemung group near Leon, Conewango and Randolph in Cattaraugus County, N. Y.

The Dalmanella leonensis zone.—Investigations into the range of the species of the genus in the Watkins Glen thirty-minute quadrangle show that the small form *Dalmanella leonensis* is confined to the lower one hundred feet (or a little over) of the Cayuta member of the Chemung formation. As it is often quite abundant in that zone the name *Dalmanella leonensis zone* is appropriately applied to it.

Common associated species of the faunule are: *Leptostrophia interstitialis*; *Productella spinulicosta*; *Spirifer disjunctus*; *Reticularia laevis*; *Palaeoneilo brevis*; *Pterinea chemungensis*.

Above the zone of *Dalmanella leonensis* the species *D. tioga* appears and in the sections along the meridian of Ithaca ranges upward through the Cayuta and Wellsburg members of the Chemung formation.

Spirifer disjunctus (Sowerby) may be regarded as a diagnostic species of the Chemung formation throughout New York state and its extension into Pennsylvania, Maryland, and Virginia. There are cases

¹ *Paleontology of New York*, Vol. IV (1867), p. 59.

² *Op. cit.*, Vol. IV (1867), p. 62.

of report of the species from rocks believed to be of a lower horizon than Chemung, but in several doubtful cases of this kind investigation has shown the absence of any conclusive evidence that the species was actually derived from the horizons mentioned.¹ In all cases in which the evidence is at hand for critical study no fauna containing authentic specimens of *Spirifer disjunctus* has been seen in New York or adjoining territory which upon any other kind of evidence can be satisfactorily thrown into a stratigraphic horizon below the base of the Chemung formation.

Many other species than those above mentioned have been listed from the Chemung formation, and they also may be recognized as good Chemung species; but it is important here to determine which particular species are diagnostic of the typical Chemung fauna, in order to establish an exact standard from which to trace the formation beyond the locality of its original definition.

In drawing the lines for the Watkins Glen quadrangle map the base of the Chemung formation has been discriminated by means of the above listed species. The formation line is thrown down as low as any of these diagnostic species have been certainly detected. This line has proven to be drawn consistently with the observed stratigraphy and conforms to the structural facts. This revision puts the line stratigraphically higher by some two hundred feet than I located it in 1884.² The faunule of Station No. 58 of that paper contains a species of *Productella* which I then identified with *P. lachrymosa*, and also the following species: *Ambocoelia umbonata* var. *gregaria*, *Orthis impressa*, and *Atrypa reticularis*. The faunas listed as 62a and 62b contain *Lingula complanata* and *Spirifer (Delthyris) mesicostalis*. All these are now thrown below the base of the Chemung, because of absence in them of the diagnostic species above cited.

The Van Etten Zone of Tropidoleptus.—The portion of the column thus thrown down from the Chemung into the upper part of the Nunda

¹ See Prosser, "The Devonian System of Eastern Pennsylvania and New York," *U. S. Geol. Survey, Bull.* 120 (1894), p. 12; Also Williams, "On the Formational Correlation of the Catawissa Section," in *Contributions to Devonian Paleontology*, *U. S. Geol. Survey, Bull.* 244, pp. 78 ff., 1905.

² "On the Fossil Faunas of the Upper Devonian," *U. S. Geol. Survey, Bull.* 3, p. 21.

upon paleontological evidence has been called the Van Etten zone of *Tropidoleptus*, for the expression of it seen in the rocks about Van Etten near drainage level. It was not known to contain *Tropidoleptus* in 1886, when I published the paper on the classification of the Upper Devonian.¹ Since then the fauna has been detected in several places. When well developed it contains the following species: *Tropidoleptus carinatus*; *Rhipidomella vanuxemi*; *Productella spinulicosta*; *Ambocælia umbonata*; *Lingula complanata*; *Spirifer marcyi*; *Delthyris mesicostalis*.

Specimens of the latter species in external appearance are often very similar to the ordinary type of *Spirifer mucronatus* (= *pennatus*) of the Hamilton group.

Associated with these diagnostic species the fauna also contains species of the following genera, viz: *Leiorhynchus*, *Leptodesma*, *Palaeoneilo*, *Grammysia*, *Modiomorpha* (*Cypricardella* is not generally with it), *Bellerophon*, *Coleolus*, *Pleurotomaria*, *Loxonema*, *Platyceras* and occasionally *Orbiculoidea*, *Chonetes* and *Camaro-toechia*.

One of the best places to see the fauna is in the ravine above White Church in the Dryden quadrangle, where it lies about two hundred feet below the base of the Chemung. On passing eastward the rocks of the upper part of the Nunda become more and more fossiliferous, and other species come in and probably other zones of the *Tropidoleptus* fauna; but in the Watkins Glen quadrangle this fossiliferous zone is frequently seen in the more eastern sections below the typical Chemung fauna, carrying several species which are common above, but never any of the species indicated above as diagnostic Chemung forms.

In the sections about Ithaca, traces of this same fauna are seen near the base of the Ithaca member in the zone I referred to in 1882² as a recurring Hamilton fauna. Since that paper was written the *Tropidoleptus carinatus* has been noted at the same horizon.

When these recurrences take place in the Watkins Glen quadrangle below the range of *Delthyris mesicostalis*, but above the Hamil-

¹ *Proc. A. A. A. Soc.*, Vol. XXXIV (1886), pp. 222 ff.

² "The Recurrence of Faunas in the Devonian Rocks of New York," *Proc. A. A. A. Soc.*, Vol. XXX (1882), p. 189.

ton, the horizon is (recognized as) in the Ithaca member of the Nunda; when the *Delthyris* is associated with them, but below the place of first appearance of the diagnostic Chemung species, the horizon is upper Nunda: i. e., the Van Etten zone of *Tropidoleptus*. Still later, after the Chemung species were upon the ground, in the lower part of the zone of *Dalmanella tioga*, *Tropidoleptus* again occurs. It is this third stage of its recurrence that was referred to in the list of species given on p. 24, of Bulletin No. 3 of the U. S. Geological Survey. It was numbered A⁶ + and called "the second recurrence of the *Tropidoleptus* stage" in my paper on the classification of the Upper Devonian in 1886.¹

The line thus determined as the horizontal boundary between the Nunda and the Chemung is traceable eastward as well as westward, by the range of the fossils which furnish a definite paleontologic means of discriminating the Chemung formation throughout its geographic extent.

The references to *Dalmanella* in *Contributions to Devonian Paleontology* of 1903² have been re-examined critically in the light of these investigations. All the citations of *Dalmanella tioga* and *D. carinata* are correct and the horizons containing them are unmistakably Chemung. The reference to the species *Dalmanella tenuilineata*, on p. 33 faunule 1379B, is based on a single specimen, and the species is the one described by Hall under the name *Orthis leonensis*.

The specimens identified, on pp. 36 and 37, as *Dalmanella tenuilineata* (from faunules 1380B⁶ and B⁷) are in both cases associated with *Spirifer disjunctus* leaving no doubt as to the horizon, but they are specimens of a small Schizophoria and should not be referred to the genus *Dalmanella*. The specimen identified as *Dalmanella* in faunule 1453A³ on p. 70, does not exhibit the characteristic features of *Dalmanella*.

In using the faunal method of determining the boundary line between the Nunda and Chemung the assumption is made that a faunal distinction was applicable to the Chemung group as originally defined by Hall. This assumption is borne out by the later experience of paleontologists in finding distinct evidence of this fauna in

¹ *Proc. A. A. A. Soc.*, Vol. XXXIV (1885), p. 226.

² *U. S. Geol. Survey, Bull.* 244 (1905).

widely diverse regions of the United States. The attempt is made in the present discussion by close analysis of the fauna at the typical locality, to ascertain the particular species whose appearance in the strata begins at a definite horizon. This analysis has furnished the practical basis for drawing the line across the Watkins Glen quadrangle.

In order to explain the fact of such a definite change in the fauna at such a boundary line, it has been necessary to assume an incursion of the Chemung fauna from outside into the region at a particular point of time. Thereafter, for a considerable length of time, the species of fossils represented in the rocks were of the same fauna and constitute the typical Chemung fauna.

However, it must be distinctly remembered that such an assumption involves the pre-existence of the fauna in full vigor prior to the time of its incursion into this region.

If we were to assume that the species of the Chemung fauna were directly evolved from species living in the same region when the underlying rocks were being deposited, the sharpness of the line would necessarily be lost and no definite boundary horizon could be drawn on the basis of fossil faunules alone; for the reason that the change in specific character does not take place at such a rapid rate that the differences could be detected.

It is therefore considered to be a confirmation of the hypothesis of incursion of the fauna that the stratigraphic line marking the first appearance of the chief diagnostic species of the Chemung fauna occurs at a horizon so consistent with the general structure of the strata of a thirty-minute quadrangle. Another confirmation of the theory comes from the geographical extension of that horizon. On passing westward from the Ithaca meridian the line of separation of the faunas becomes more sharp and distinct; while on passing eastward the fauna below the line contains more and more species which are also found above the line.

In this eastern extension of the line, however the distinctive Chemung species become less dominant and as has been shown in earlier papers, the reappearance of species, which in the western New York outcrops are confined to horizons far below the boundary, is observed to be the rule rather than an occasional exception.

We are thus forced by the study of the facts, to the opinion that the horizon which is thus drawn on the basis of a change of the fossil faunas in the strata, while it represents at any one spot a definite point in geologic time, does not represent the same point of time in the sections of separate regions.

We are warned by the reappearance of many of the species of the Independence shale of Iowa in the fauna at the top of the Iowa Devonian series (Lime Creek shales), against the assumption that the same horizon is always indicated by the same fauna.¹ Correlation by faunas is always subject to the criticism that the mere presence of a fossil indicates only some point of time during the life history of that species. Nevertheless, in a restricted region, such as the one now under investigation, the first appearance in the stratigraphic column of a definite fauna, defines a definite geologic horizon with a high degree of precision. And so long as correlations are extended from the typical outcrop within the same geologic basin, the transition from one fauna to the next higher may be depended upon as marking the same point in the faunal histories whether they be considered as synchronous or only homotaxic.

¹ Calvin, *Iowa Geol. Surv.*, Vol. VIII, p. 222.